MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 2, 2015/2016**

## EEL1206 – INTRODUCTION TO MACHINES AND POWER SYSTEMS

( EE, CE, MCE, ME, TE, OPE, NT )

8 MARCH 2016
2.30 p.m - 4.30 p.m
( 2 Hours )

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**INSTRUCTIONS TO STUDENTS**

1. This question paper consists of 8 pages with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

## Question 1

(a) A motor is supplying 50N-m of torque to its load. If the shaft of the motor is turning at 1200r/min, determine the mechanical power supplied to the load in watts and in horsepower. [3 marks]

(b) A ferromagnetic core with a relative permeability of 2000 is shown in Figure Q1A. The dimensions are shown in the diagram. The depth of the core is 5cm and there are 100 turns on the leftmost leg. Due to the fringing effects, the effective areas of the air gaps are 5% larger than their physical size. The permeability of the air, $\mu_0 = 4\pi \times 10^{-7} NA^{-2}$.

i. Sketch the magnetic circuit. [2 marks]

ii. Determine the total reluctance of the core? [10 marks]

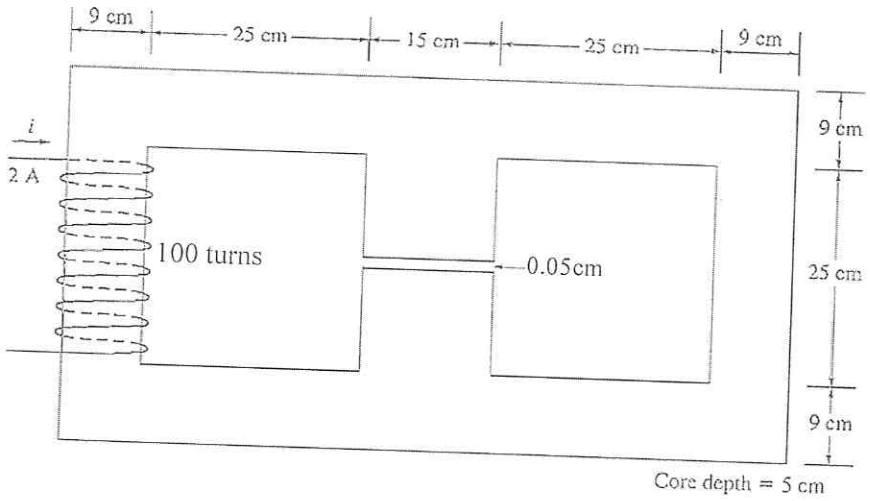


Figure Q1A

Continued...

(c) A wye-connected balanced three-phase generator connected to a Δ-connected balanced load with impedance of $Z_a = Z_b = Z_c = 150\Omega$ per phase as shown in Figure Q1B.

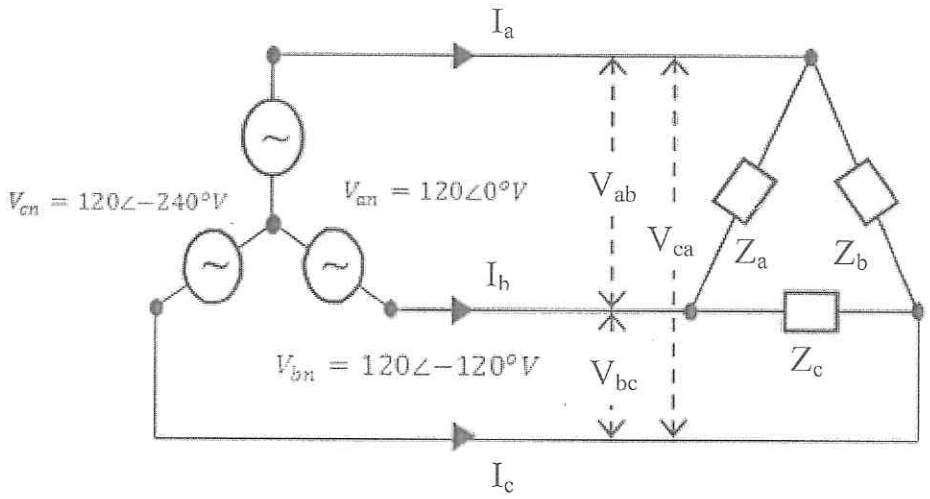


Figure Q1B

Assuming a positive sequence for the source voltages:

i. Convert the Δ-connected load to a Y-connected load. [4 marks]

ii. Find the line voltages, $V_{ab}$, $V_{bc}$ and $V_{ca}$. [6 marks]

Continued...

## Question 2

(a) A short circuit test has been carried out on a 10MVA, 66kV/13.2kV single-phase transformer, the results obtained is summarize in Table Q2.

| $V_{sc}$ | $I_{sc}$ | $P_{sc}$ |
|---|---|---|
| 2400V | 60A | 10kW |

Table Q2

Calculate the following:

i. The transformer turn ratio, a. [2 marks]

ii. The total resistance, $R_{eqp}$ and the total leakage reactance, $X_{eqp}$ referred to the primary side. [5 marks]

iii. Full load efficiencies of the transformer if the iron losses at rated voltages are 35kW and power factor of the load is 0.85 lagging. [5 marks]

(b) A 20kVA 8000/277V distribution transformer has the following resistance and reactance:

$R_P = 32\Omega$, $X_P = 45\Omega$, $R_C = 250k\Omega$
$R_S = 0.05\Omega$, $X_S = 0.06\Omega$, $X_M = 30k\Omega$

The excitation branch impedances are given referred to the primary side of the transformer.

i. Determine the secondary impedance of this transformer referred to the primary side. [5marks]

ii. Determine the transformer's input voltage, when this transformer is supplying rated load at 277V and 0.8PF lagging. [6 marks]

iii. What is its voltage regulation under the conditions of part (ii)? [2 marks]

Continued...

## Question 3

(a) There are two general types of armature windings in **DC machines**: lap winding and wave winding. Compare the characteristics of the two winding types in Table Q3 below. To compare the configurations, refer to Figure Q3A for a 4-pole system.

| **Characteristics** | **Lap Winding** | **Wave Winding** |
|---|---|---|
| Voltage & Current (Low/High) | | |
| Number of brushes | | |
| Number of parallel path | | |
| Current for each path | | |
| Configurations | | |

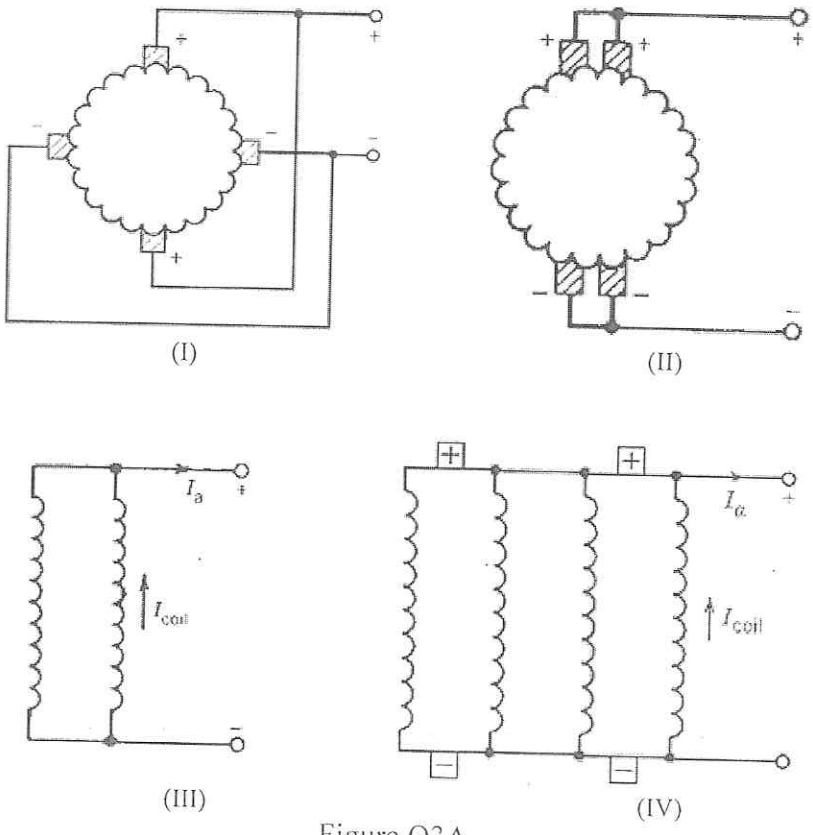


Figure Q3A

[10 marks]

Continued...

(b) A short-shunt compound **DC generator**, as shown in Figure Q3B, has following data:

Rated power $P_{out}$= 30kW,

Rated terminal voltage $V_t$ = 300V,

Armature resistance $R_a$ = 0.08Ω,

Series field resistance $R_s$ = 0.1Ω, and

Shunt field resistance $R_f$ = 155Ω

Determine the following:

i. Load current $I_L$ . [1 mark]

ii. Field voltage $V_f$ . [2 marks]

iii. Field current $I_f$ . [1 mark]

iv. Armature current $I_a$ . [1 mark]

v. Induced voltage $E_g$, if the brush contact drop is around 2V. [2 marks]

vi. Efficiency $\eta$, if the rotational losses is around 100W. [3 marks]

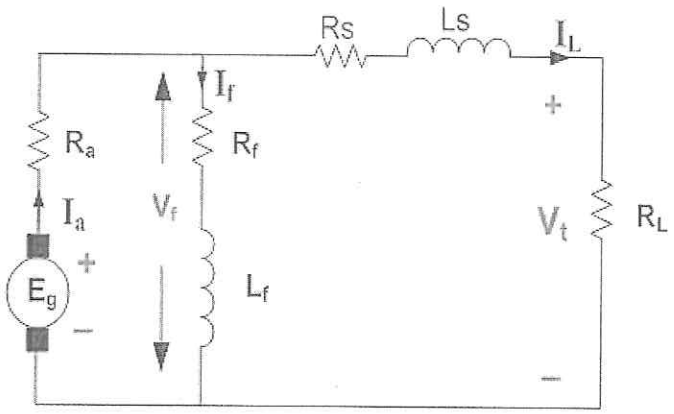


Figure Q3B

(c) A 200V, 2-pole, 50Hz, Y-connected **induction motor** has a full-load slip of 8%. Calculate the synchronous speed $n_{sync}$, as well as the actual rotor speed $n_m$ at rated load for this motor. Briefly explain why induction machines will always run at a speed lower than the synchronous speed. [5 marks]

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## Question 4

(a) Figure Q4A depicts the simplified flow diagram of a hydroelectric generating station supplying electric power to a load with fluctuating power demand. Explain how stability is maintained in the system. [5 marks]

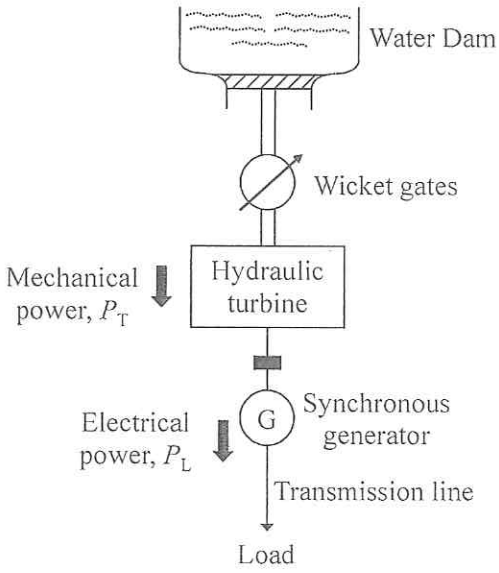


Figure Q4A

(b) Figure Q4B on the next page illustrates the one-line diagram of a power system. The ratings of the various components in the system are given as follows:

G1: 100MVA, 24kV, $R = 5\%$, $X = 80\%$

G2: 200MVA, 24kV, $R = 10\%$, $X = 80\%$

T1: 80MVA, 24kV/220kV, $R = 1\%$, $X = 10\%$

T2: 50MVA, 240kV/14.4kV, $R = 1\%$, $X = 10\%$

M: 75MVA, 12kV, $R = 12\%$, $X = 90\%$

The transmission line has an impedance of $(25 + j50)\Omega$, and the static load impedance is $(2.25 + j2.63)\Omega$. Consider a base apparent power of 100MVA and a base voltage of 24kV at the generator side.

(i) Determine the base voltages and impedances in Regions 1, 2 and 3. [5 marks]

(ii) Find the per-unit values for all the impedances. [6.5 marks]

(iii) Draw the impedance diagram of this power system, and label all the impedances in per-unit. [3.5 marks]

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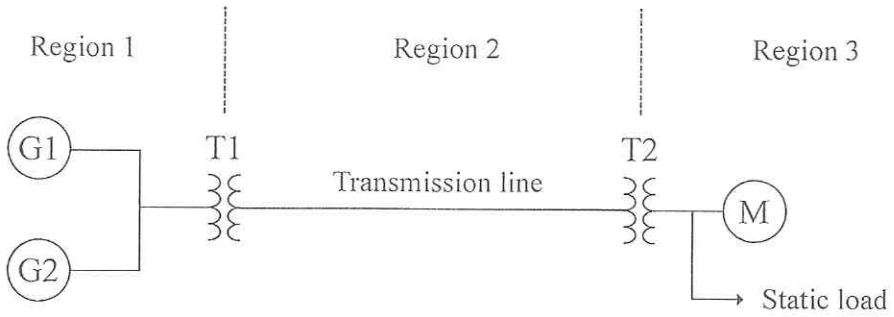


Figure Q4B

(c) An Inverse Definite Minimum Time (IDMT) overcurrent relay is used to protect a distribution feeder. The time-delay characteristic of the relay is as shown in Figure Q4C. The relay is connected to a 600:5 current transformer and a circuit breaker, and is set to operate when the load current on the feeder exceeds 480A. For a chosen time-dial setting of 5, determine the operating time of the relay for a fault current of 1680A. [5 marks]

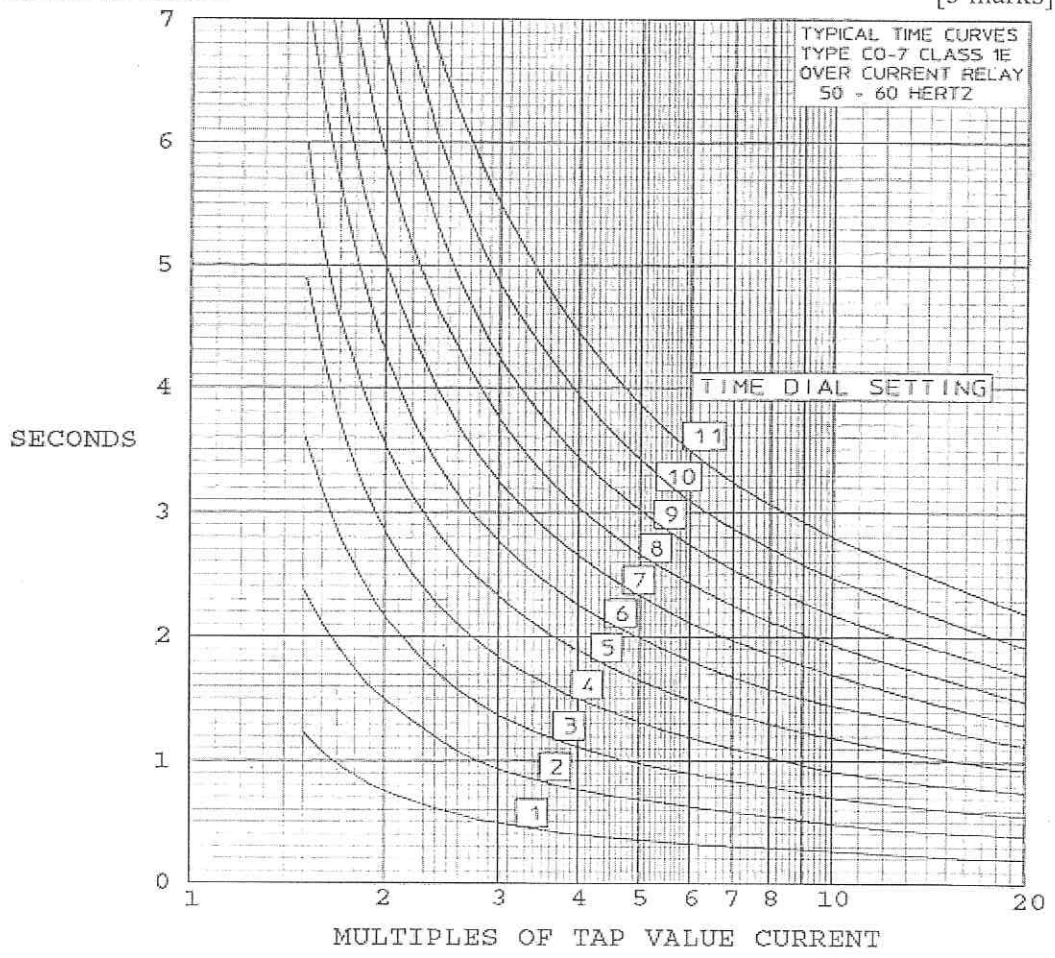


Figure Q4C

**End of Paper**